California Energy Commission (CEC)

Food Industry PQ Initiative

An Application Oriented R&D Program

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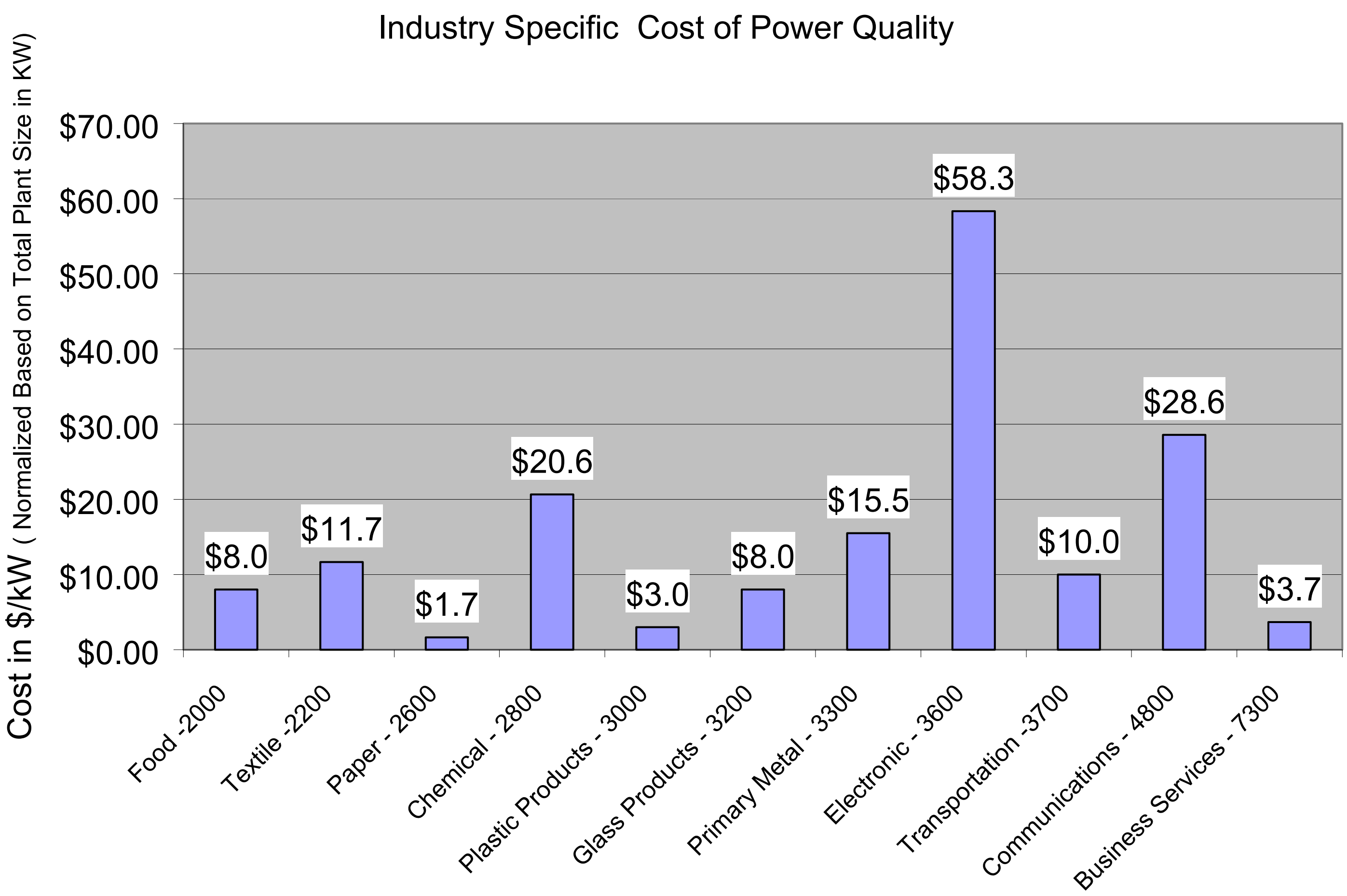
April 23, 2002

Del Monte Foods

Modesto #1

The Societal Cost of PQ



Source: PQ Investigations and Industry Contacts

Importance of Food Industry to CA

Nondurable Goods	**720,000**	**-0.2**	**-0.3**
Food & Kindred Products	183,300	-0.2	2.1
Textile Mill Products	26,800	7.7	5.9
Apparel & Other Textile Pro	144,100	-4.1	-3.7
Paper & Allied Products	39,400	-1.5	-1.5
Printing & Publishing	149,900	1.5	-1.3
Chemicals & Allied Product	79,100	5.5	5.6
Petroleum & Coal Products	18,400	-2.9	-7.5
Rubber & Misc. Plastics Pro	72,300	-1.8	-2.7

Source: Economic Report of the Governor, 2000, Manufacturing Employment

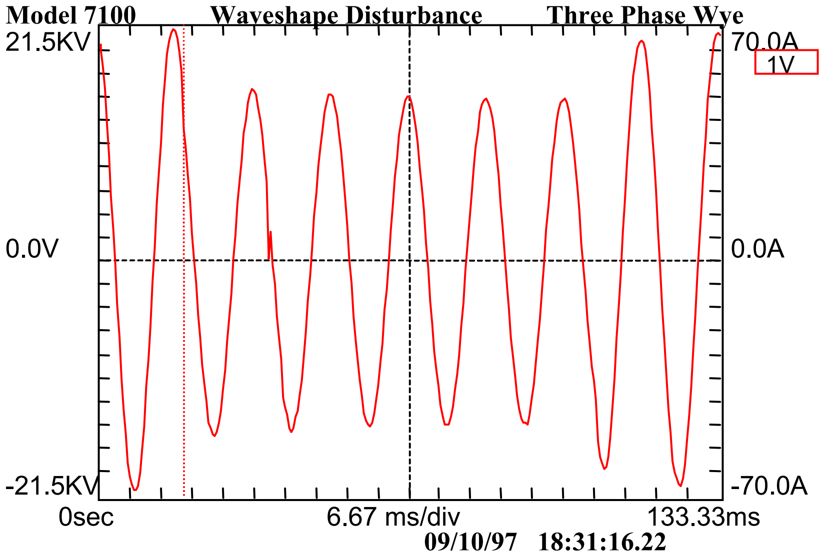
Increased Power Quality Requirement Because of……

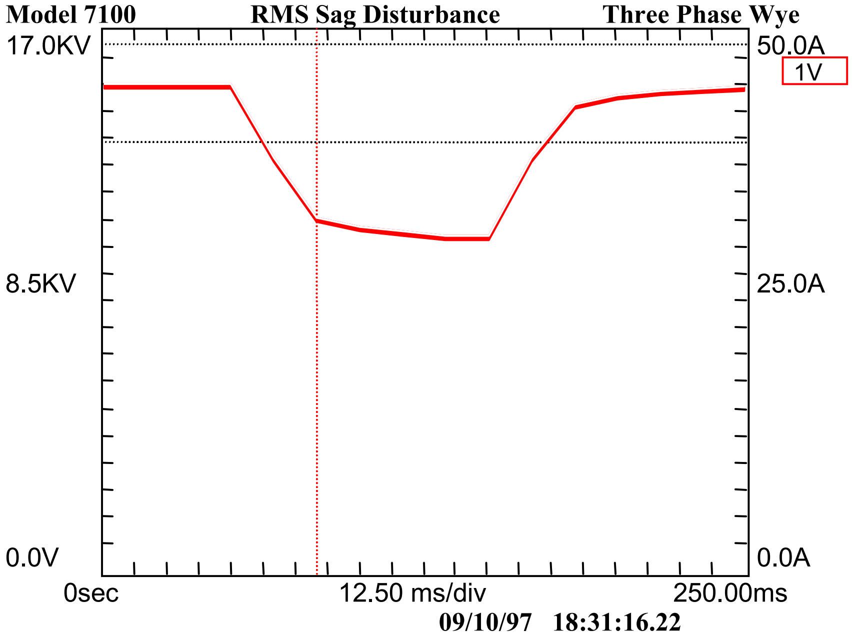
- Advances in microelectronic.
- Increase in automation.
- Change in process from batch to continuous flow.
- Replacement of electromechanical controls to electronic controls.
- Computers moving from the computer room to office and production floors.
- Continuous around-the-clock 24/7 operation.

Quality versus Reliability

- Reliability
  - Power “On” or “Off.”
  - Outages.
  - Customer’s understand outages and can live with them if the frequency and duration are minimized.
- Power Quality
  - Temporary deviation from normal (milliseconds to seconds).
  - Disrupts process operation for no apparent reason.
  - Customers have difficulty understanding why the “Blink” happened on a clear day!!

Quality versus Reliability





Large Industrial Customer: Perfect Power from Reliability Perspective (0 outages)

On average, customer experiences 10 voltage "Blinks" per year that cause process disruptions.

Is the reliability of power adequate?

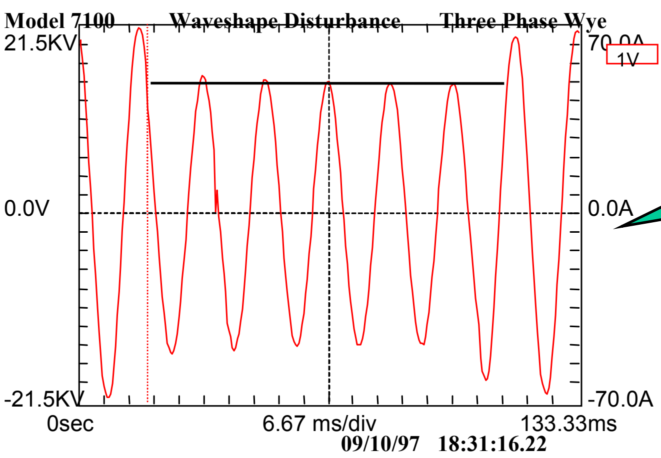
Is the quality of power adequate?

Does Reliability = Quality?

Quality of Power – Perception & Reality

Electric utility definition of *service interruption* will differ from customer perception of *service interruption* as load sensitivity increases.

70% of Nominal for 1/8 sec



Is this a service interruption ?

The Spectrum of Power Quality Variations

Categories	Spectral Content	Typical Duration	Typical Magnitudes
1.0 Transients			
1.1 Impulsive			
1.1.1 Voltage	> 5 kHz	< 200 µs	
1.1.2 Current	> 5 kHz	< 200 µs	
1.2 Oscillatory			
1.2.1 Low Frequency	< 500 kHz	< 30 cycles	
1.2.2 Medium Frequency	300–2 kHz	< 3 cycles	
1.2.3 High Frequency	> 2 kHz	< 0.5 cycle	
2.0 Short-Duration Variations			
2.1 Sags			
2.1.1 Instantaneous		0.5–30 cycles	0.1–1.0 pu
2.1.2 Momentary		30–120 cycles	0.1–1.0 pu
2.1.3 Temporary		2 sec–2 min	0.1–1.0 pu
2.2 Swells			
2.1.1 Instantaneous		0.5–30 cycles	0.1–1.8 pu
2.1.2 Momentary		30–120 cycles	0.1–1.8 pu
2.1.3 Temporary		2 sec–2 min	0.1–1.8 pu
3.0 Long-Duration Variations			
3.1 Overvoltages		> 2 min	0.1–1.2 pu
3.2 Undervoltages		> 2 min	0.8–1.0 pu
4.0 Interruptions			
4.1 Momentary		< 2 sec	0
4.2 Temporary		2 sec–2 min	0
4.3 Long-Term		> 2 min	0
5.0 Waveform Distortion			
5.2 Voltage	0–100th Harmonic	steady-state	0–20%
5.3 Current	0–100th Harmonic	steady-state	0–100%
6.0 Waveform Notching	0–200 kHz	steady-state	
7.0 Flicker	< 30 Hz	intermittent	0.1–7%
8.0 Noise	0–200 kHz	intermittent	

10

to

1*

Source: IEEE P-1159

The Experience We Bring: System Compatibility Research Project by Equipment/Device

VFD's, tasks 1, 12,26,39

PLC's, task 5

Servo's, task 14

Motor variable torque loading, task 26

Devices for industrial control ride thu, task 31

MCC's and control logic, task 32

CNC machines, task 33

Chillers, task 34

EPRI

Announcing

May 1998 Testing Opportunity

Task 14: Characterization of PLC-Based Servo Control Systems

Background

In the manufacturing environment, programmable logic controllers (PLCs) are integrated with various process control devices and instrumentation. Servo-motor systems that depend on supervisory PLC control are vital to certain process tasks. A typical use of PLC-based servo control is in manufacturing processes where precision handling of materials is required, such as conveying, cutting, packaging, and wrapping. Because continuous operation of these processes is important to industrial utility customers, electric utilities recognize the need to characterize the immunity of automated systems to voltage fluctuations. Several utilities have therefore asked PEAC to continue the characterization of automated control systems begun in Task 5: Programmable Logic Controllers.

Objective

The main objective of Task 14 is to explore ways to make automated servo control systems more immune to voltage fluctuations. The primary goals of Task 14 are to:

- Compile important power quality issues related to PLC-based servo control systems.
- Create performance criteria for the response of these systems to electrical disturbances.
- Develop general guidelines for making these systems less susceptible to electrical disturbances.
- Raise the general awareness of typical power quality problems in these systems by sharing case studies from voltage-sag testing at numerous industrial facilities.

Task Description

To better characterize the performance of PLC-based servo control systems during electrical disturbances, PEAC is proposing a milestone approach to Task 14:

- Specify, design, and build a model PLC-based servo control system in the PEAC laboratory using standard PLC and servo control technologies. The model system will follow conventional design to reflect typical factory systems.

The Servo-Control Test Stand will enable investigators to run automated servo control sequences while subjecting the system to electrical disturbances. The test results will help Task sponsors quickly identify susceptibilities of particular control schemes.

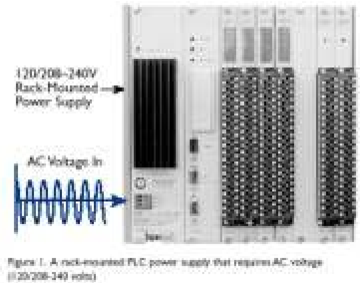
The PLC Test Program

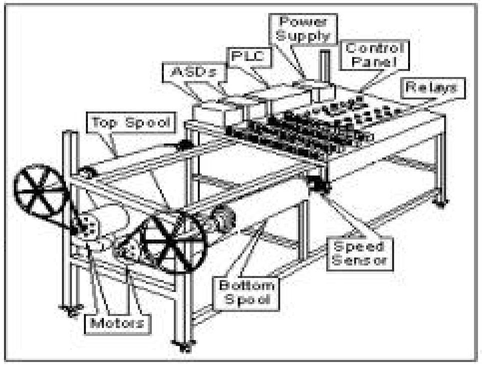
Product	Manufacturer	Relative I/O Capability	Target Application
984-385	AEG Schneider	medium	general purpose
Micro 984	AEG Schneider	small	OEM machinery /small application
PLC-5/11	Allen Bradley	small-medium	general purpose
SLC-5/02	Allen Bradley	small	OEM machinery/small application
9000E	Honeywell	medium	process applications
SIMATIC TI-545	Siemens	medium	process applications
SYSMAC CVM-1 CPU21-V2	Omron	medium	general purpose

PLCs and Industrial Controls

System Compatibility and Reliability Testing of Industrial Control Devices and Process Mockups;

- Ride-Through Characteristics of PLC AC and DC Power Supplies
- Performance of AC Motor Drives During Voltage Sags and Momentary Interruptions
- Performance of a Hold-In Device for Relays, Contactors, and
- Motor Starters





The “Real Word” Experience We Bring…

Georgia Pacific
ALCOA
DuPont
Motorola
Pennzoil
Allied Signal
Baltimore Sun
Lucent Technologies
Nestle
Various Government Agencies
Hughes
Folgers Coffee
Hilton Hotels
Numerous Hospital Facilities
Motorola
Mohawk Carpets
Outdoor Technologies

IBM
Pratt and Whitney
Nissan
Citicorp
Chevron Chemicals
Amoco Polymers
Toyota
General Electric
Yeager International Airport
Santa Barbara Airport
Countrymark
Washington National Airport
World Bank
Pittsburgh Plate Glass
International Rectifier
PBR Automotives
Bonolac Foods

From Specific PQ Investigation to Industry Initiatives: The SEMI Model

Standards Org

- SEMI
- SEMATECH
- SEMI/SEMATECH

EPRI/PEAC

Electric Utility

- Central Hudson
- Duke Power
- Green Mountain Power
- Public Service New Mexico
- Salt River Project
- San Diego Gas and Electric
- TU Electric
- Others

Semi-Industry Consultants

- Blake Technologies, Inc.
- EMRO, Inc.
- FOA, Inc.
- Others

OEM Equipment & Tool Vendors

- Applied Materials
- CFM Technologies
- LRC
- Reliability Inc.
- FSI
- Rudolph
- ASM
- SCP Global
- Stellar Dynamics
- Square D/Groupe Schneider

Semiconductor Manufacturers

- IBM
- Intel
- Motorola
- Texas Instruments
- Others

The Outcome of SEMI Project

- Equipment tolerance standard and test protocol from SEMI standard (SEMI F47 and SEMI F42 Standard)
- Facility Design Guideline
- Utility Electric Environment Guidelines
- A paradigm shift in resolving incompatibility issues
- Suppliers of equipment to IBM, Motorola, Intel, etc. are now actively engaged in testing their equipment and specifying their response to electrical disturbance
- The onus is not just on utilities…..

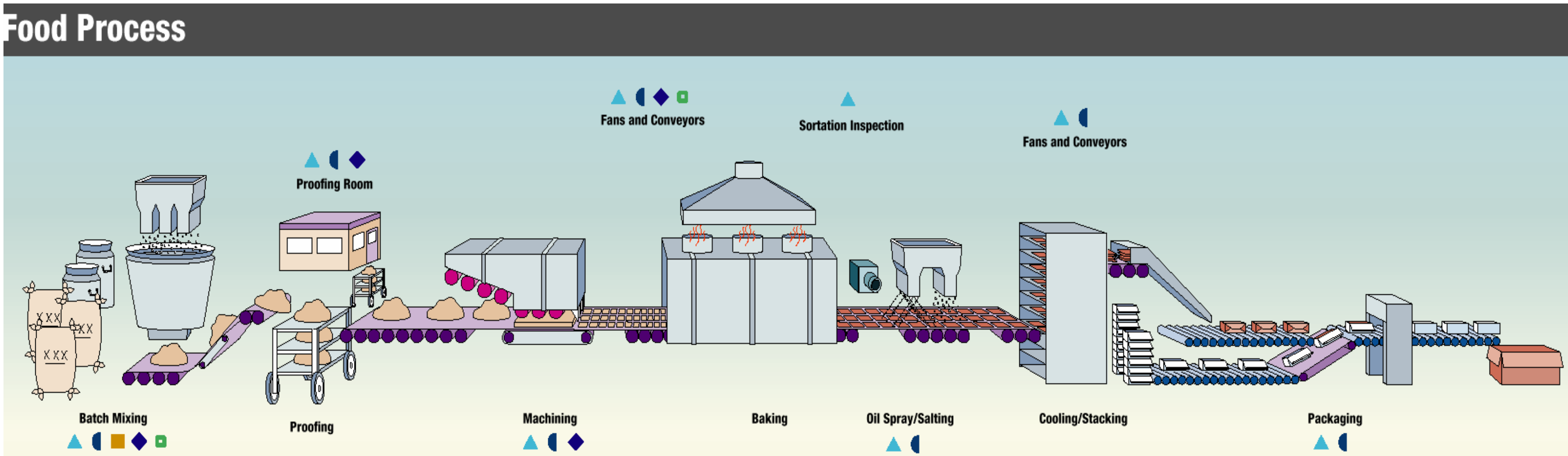
The Key to SEMI Success

- Knowing the end goal of the project.
- A small team of dedicated individuals working towards that goal.
- Semi industry ensuring that the equipment suppliers are a part of the effort
- Extensive knowledgebase on equipment sensitivity that even the equipment manufacturers were not aware of.
- Knowledgebase on PQ issues from detail semiconductor site investigations.

CA Food Industry PQ initiative

- Understanding the Dynamics of Food Processing Industry and Electrical Environment;
- Evaluating PQ sensitivities and solution approaches using candidate food industry plants;
- Developing Design Guidelines for Process Automation with PQ immunity;
- Engaging the Industry to Develop PQ Supply Chain Management Plan (Electric Utilities & Equipment Suppliers);
- Transferring the knowledge to other food industries using a Web Based Platform

Understanding Process Sensitivity to PQ Problems



The process is as robust as its “weakest link.”

Process controls are in most cases are the weakest link.

Managing PQ disturbances are often managing the weakest links in a process.

It is always cost-effective to built in PQ immunity during the design stage[

Finding the Weakest Link

Main Contactor
2 cycles,
43%

EMO Relay
1 cycles,
52%

EMO Relay
0.5 cycles,
61%

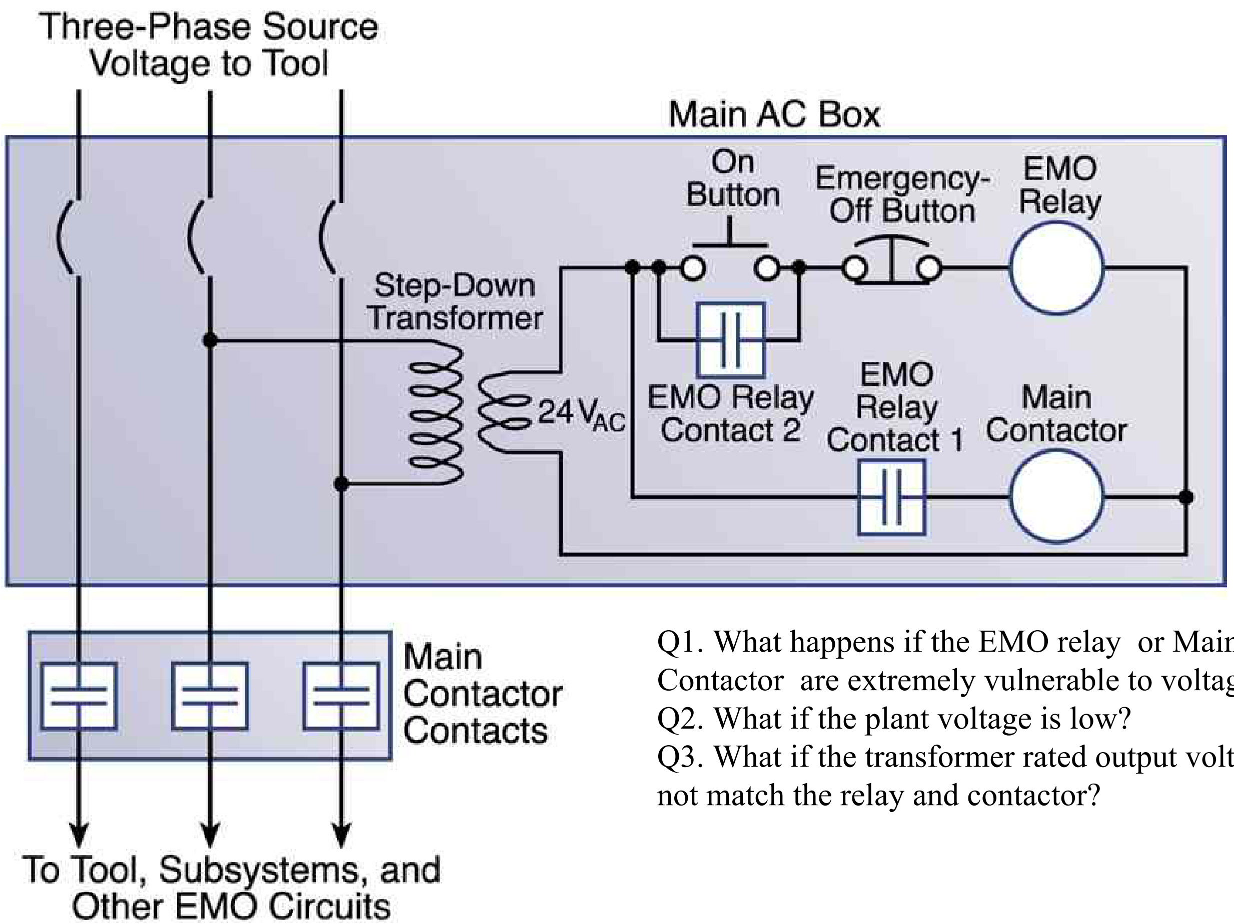
Contactor
2 cycles,
49%

EMO Relay
(next gen)
0.5 Cycles,
78%

EMO Relay
1 Cycle
45%

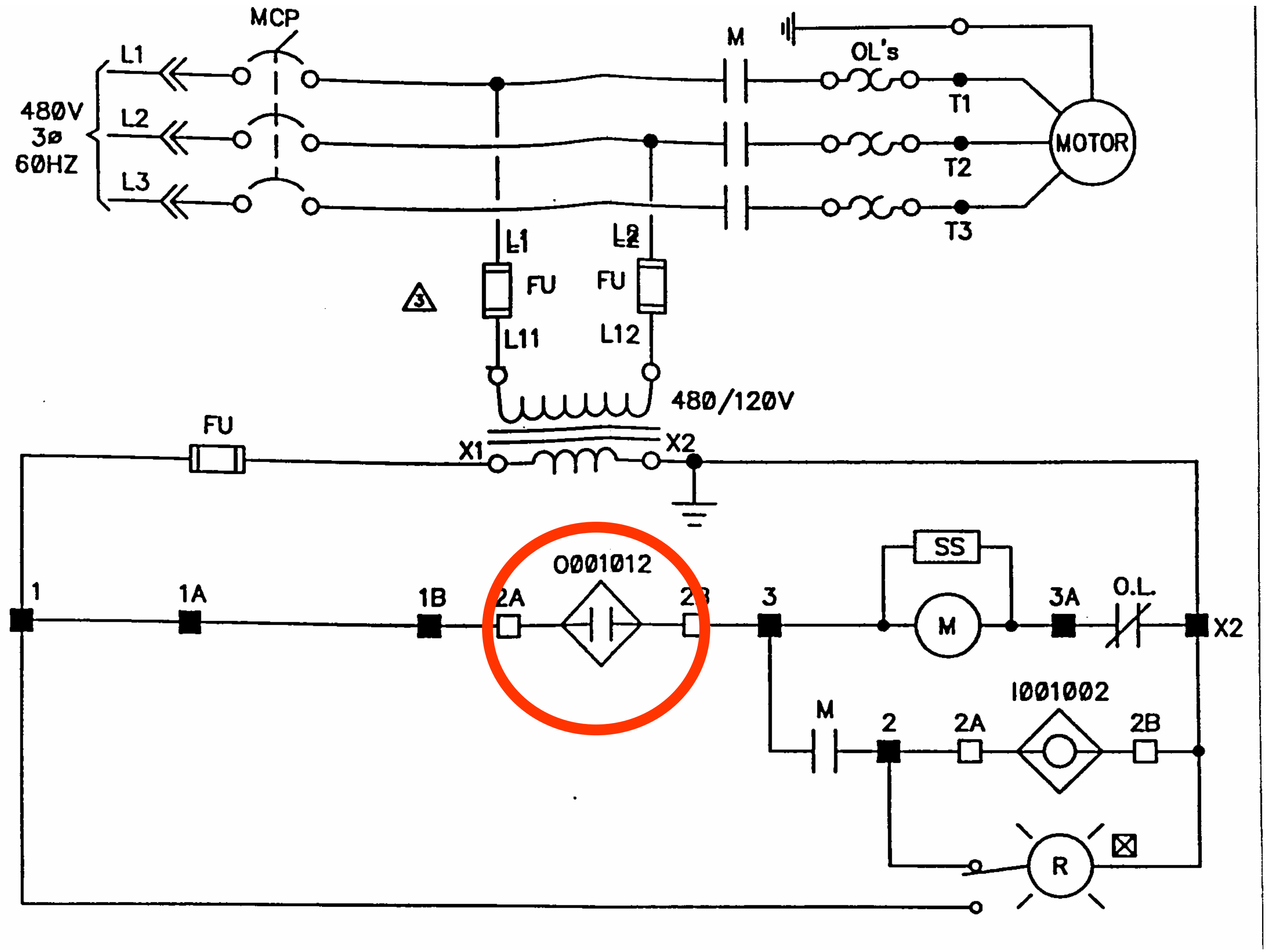
Not Shown:
EMO Relay 1 Cycle, 38%

Emergency Off (EMO) Circuit
Weak Link
(Simplified)

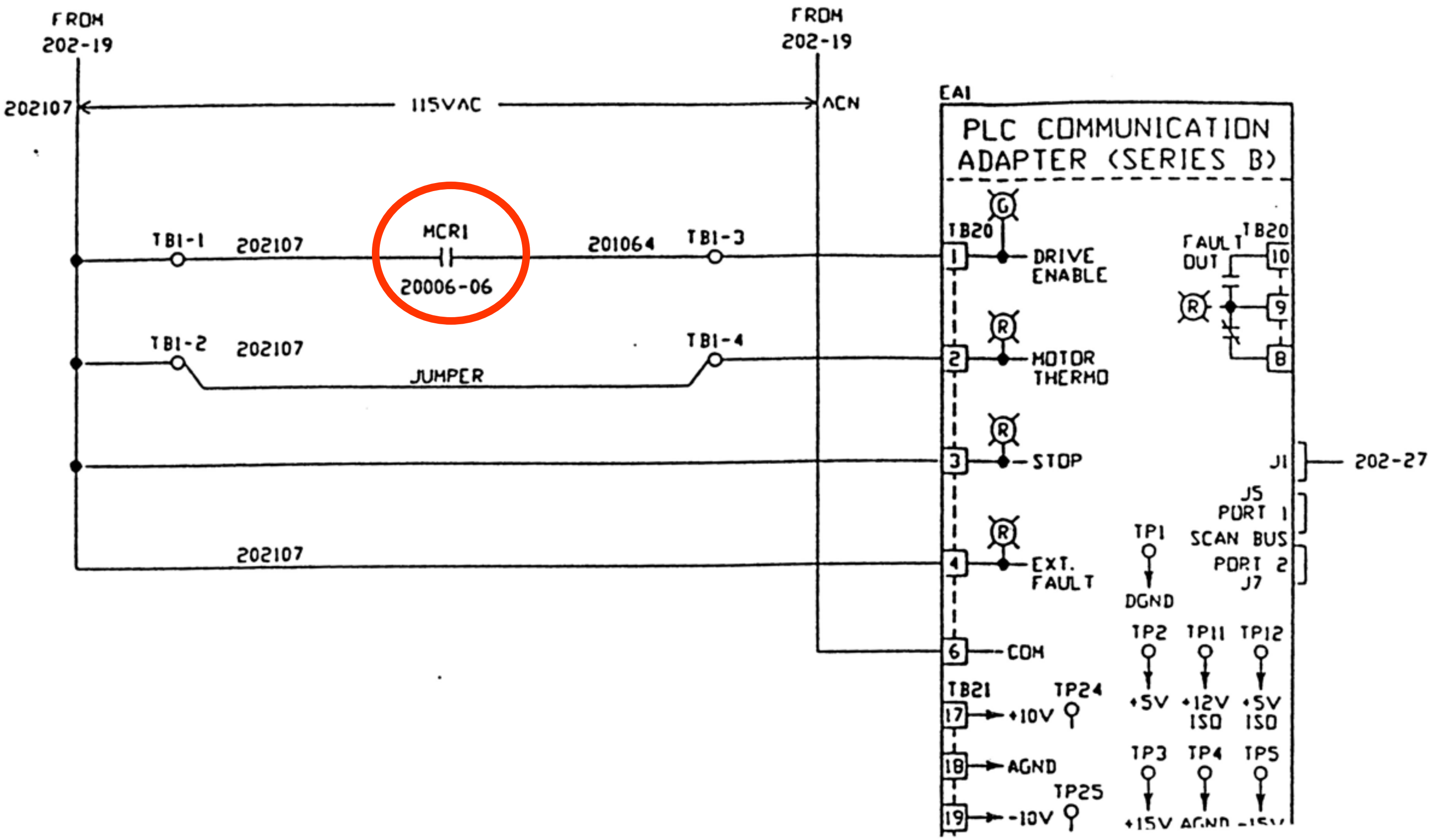


Q1. What happens if the EMO relay or Main Contactor are extremely vulnerable to voltage sags?
Q2. What if the plant voltage is low?
Q3. What if the transformer rated output voltage does not match the relay and contactor?

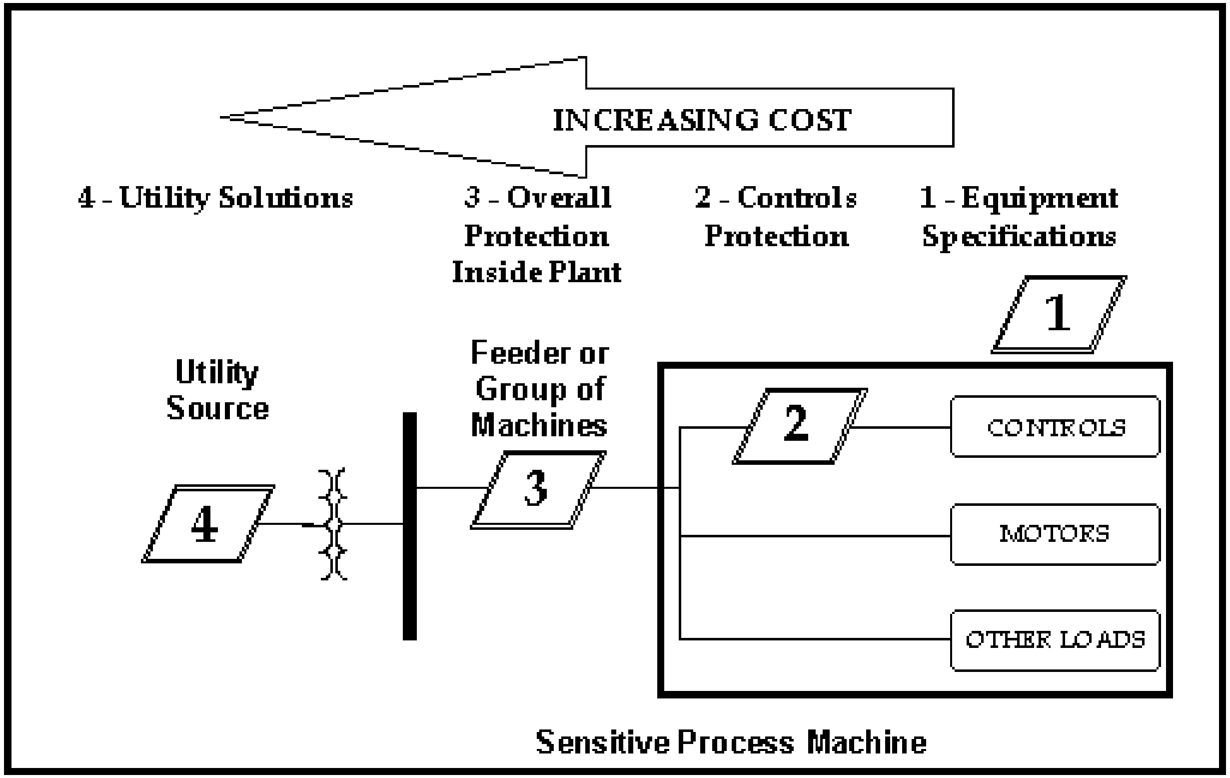
Motor Control Weak Link



Drive Weak Links: Enable Signal



Solutions to PQ Problems

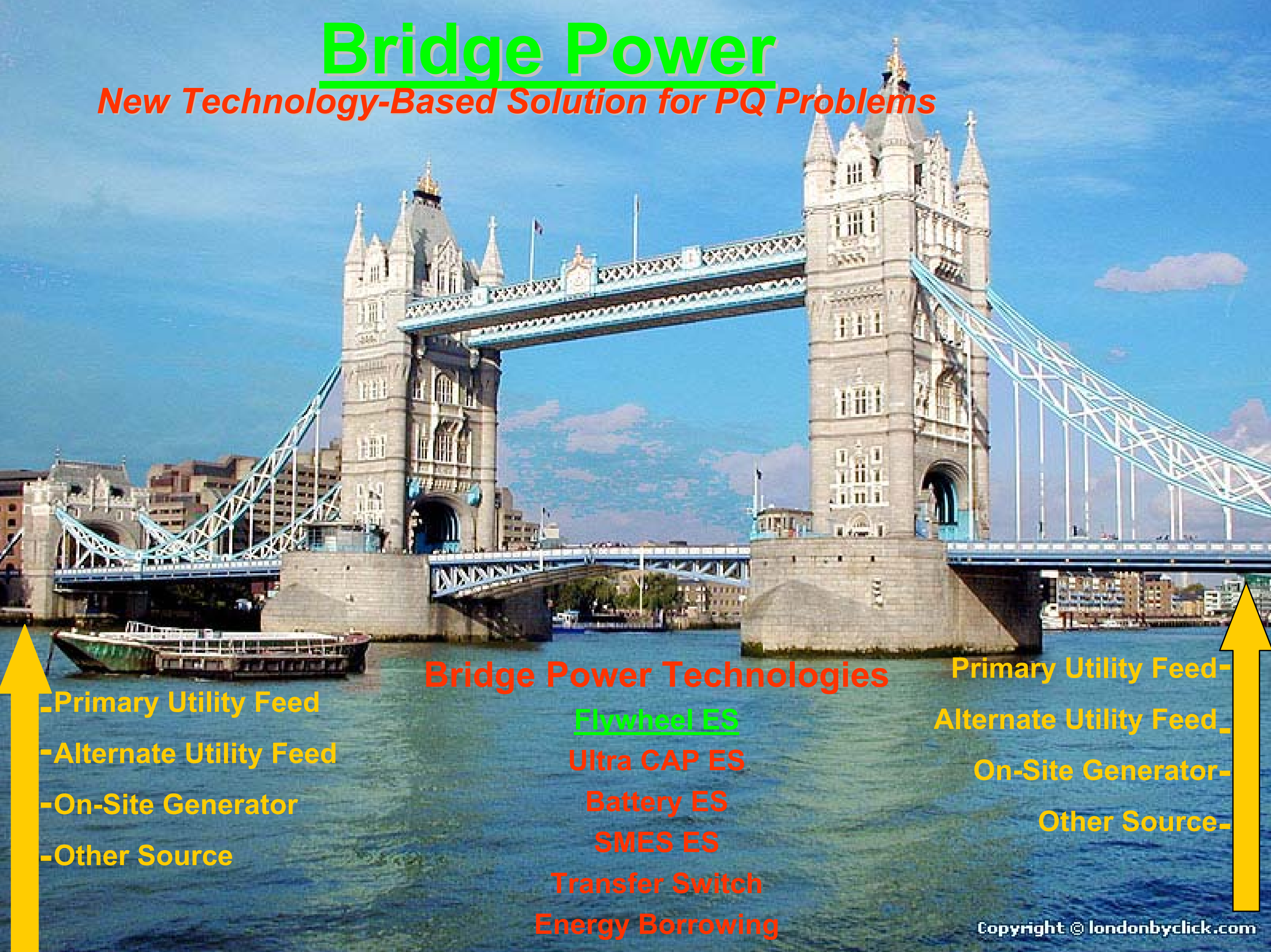


Emergence of New Technologies for PQ Solutions

- Standby generators and battery-based UPSs are solutions for outages.
- PQ solutions require short-term energy storage (seconds).
- Flywheel, ultracapacitor, and other emerging short-term energy storage solutions are often referred to as "Bridge Power."

Bridge Power

New Technology-Based Solution for PQ Problems



- Primary Utility Feed
- Alternate Utility Feed
- On-Site Generator
- Other Source

Bridge Power Technologies

Flywheel ES

Ultra CAP ES

Battery ES

SMES ES

Transfer Switch

Energy Borrowing

Primary Utility Feed -

Alternate Utility Feed -

On-Site Generator -

Other Source -

CA Food Industry PQ Partnership

- A joint industry collaboration
  - Food Processing Industry
  - Electric utility Suppliers
  - California Energy Commission
  - EPRI
  - California Institute of Food & Agricultural Research

Specific Outcome

- For participating Industries
  - Evaluating Process dynamics to PQ Disturbance
  - Evaluating “Weak Links” and targeted PQ solution
  - Development of PQ Immunity Guidelines for “new” and “existing” plants
  - Addressing the root cause of the problem
- For CA Food Processing Industry
  - Transferring the knowledge through a web based platform and industry workshop
  - An industry specific PQ Immunity standard
  - PQ Design assessment for “weak link” evaluation
  - Developing a comprehensive industry standard for long-term PQ solution instead of “fix the problem when it happens” approach.

Transferring the Knowledge to Help CA Food Industry – Web Based Industrial Design Guide

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EPRIweb

Web-Based Industrial Design Guide

Version 2.0 (December 2000)

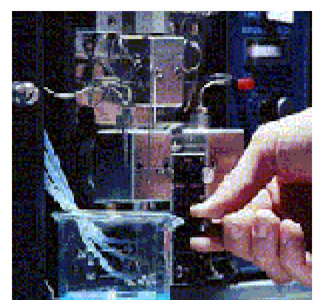
CNC / Metals Fabrication

Food Processing

Healthcare and Hospital Facilities

Industrial Machinery and Equipment

Petroleum and Chemical Processing



Pharmaceuticals Manufacture